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IDEAS OF K. E. TSIOLKOVSKIY ON ORBITAL SPACE STATIONS

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16. Abstract

K. E. Tsiolkovskiy's ideas on building orbital space stations and using them to form "rings of settlements" around planets, later to become autonomous planets circling the sun, are presented in their chronological development.

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[Paper delivered by A. I. Kol'chenko and I. V. Strazheva, USSR Academy of Sciences, Institute of History of Natural Sciences and Technology, at the Fifth Symposium on History of Astronautics at 12th Congress of International Astronautics Federation, 20-25 Sep 71]

[Text] One fundamental direction in the advances underway in modern astronautics is the building of long-lived orbital space stations orbiting about planets of our solar system. Constructing these stations is enormously important, scientifically and from the national economic viewpoint. Accordingly, interest is drawn to studying the history of the inception and shaping of the related ideas of scientists dealing with problems of the mastery of space.

The idea of building orbital space stations was first expressed and substantiated at the end of the 19th - beginning of the 20th century by the Russian scientist and founder of astronautics, Konstantin Eduardovich Tsiolkovskiy (1857-1935). During his many years of scientific creativity, the scientist again and again turned to working on this idea.

Today the portion of the rich scientific legacy of K. E. Tsiolkovskiy -- in which, in particular, questions of building orbital stations were reflected in some aspect, is kept in the Archives of the USSR Academy of Sciences and is being studied and readied for publication. In our paper we briefly review some of K. E. Tsiolkovskiy's ideas on orbital stations, by referring to his works, some not yet published.

Stored in the Archives of the USSR Academy of Sciences are some sheets and childhood notebooks of K. E. Tsiolkovskiy with his first reflections on space journeys, going back to 1878-1879 [2]. The author examines especially closely aspects of life and organization of manufacturing in outer space, devoid of gravity. One of K. E. Tsiolkovskiy's drawings shows the planet Saturn; beneath it he wrote his first hints on the possible design for an orbital station: "Phenomenon on rotating planet. One can move easily in all directions with an artificial ring, like Saturn's." [1, p 437].

From the very outset of his search to find whether space flight was possible, K. E. Tsiolkovskiy tried to show how much mankind would gain when space flight was mastered.

K. E. Tsiolkovskiy's monograph on interplanetary journeys "Svobodnoye prostranstvo" [Free Space] goes back to 1883 [1, pp 25-68]. Even at this date he so precisely described man's behavior in weightlessness that three-quarters of a century later cosmonaut Yuriy Alekseyevich Gagarin could say: "I am simply amazed how accurately our remarkable scientist chould have foreseen everything that I have just now encountered, that I had to experience for myself."

In pondering the idea of interplanetary flights and sketching an imaginary picture of the first human settlements around the earth and the minor planets, K. E. Tsiolkovskiy already quite concretely spoke of the need to build a system of orbital earth stations:

"Our planet's population in the many millions lives on only part of it," we read in his famous science fiction book "Grezy o Zemle i nebe i effekty vsemirnogo tyagoteniya" [Musings on Earth and Heaven and Effects of Universal Gravity] (1895) [3], "but for the most part, in pursuit of light and habitat, forms around the planet -- with their machines, apparatus and structures -- a moving swarm, ring-shaped, like Saturn's ring, only relatively bigger" [4, p 81].

And more: "Around this planet, precisely as around a smaller planet, there will whirl a living ring receiving energy from the sun sufficient to sustain life for 20 billions of inhabitants" [4, p 83].

In this book, K. E. Tsiolkovskiy proposed producing in the orbital stations artificial gravity by rotating the space object; changing the speed of rotation would then change the gravity force.

K. E. Tsiolkovskiy's ideas on mastering space found their scientific-technical substantiation in his work "Issledovaniye mirovykh prostranstv reaktivnymi priborami" [5] [Exploring Universal Expanses with Jet Instruments], first published in 1903 and elaborated and supplemented in editions of 1911-1912 [illegible].

"To set foot on the soil of asteroids, to lift a rock with one's hand on the moon, to place traveling stations in the airy realms, to form living rings around the earth, moon and the sun, to observe Mars at distances of several tens of verst [1.067 km] and to land on its satellite or even on its surface, what could be more mind-dazzling! Yet from the beginning of use of jet instruments will begin a new, a grand era in astronomy -- the epoch of orbital study of the heavens. The monstrous force of gravity that terrorizes us will not frighten us more than its wont!" [1, p 136]. Thus the scientist wrote in 1911, gazing into the future that has in large measure become reality in our time. He reflected on man's conquest of the limitless expanses and utilizing for the needs of all earthlings at first the sun's energy, and then the energy of other stars. In this same work of 1911-1912 he was the first

to clearly spell out his idea of building orbital stations: "Travel around the earth of several rockets, with all accessories for the existence of rational beings can serve as a base for the further propagation of mankind" [1, p 124].

K. E. Tsiolkovskiy worked out various plans for building a system of orbital stations, while dealing with other problems in his program of space conquest. The notion of building a system of orbital stations always remained with his the very heart of the practical part of his space program. He assumed that in the first stage of building this system, the chief goals of the orbital stations would be various astronomical, astrophysical, medical-biological and various engineering-physics and [illegible]-technological investigations. These investigations not only would broaden our knowledge of the universe, but would also help in working out the optimal variant for long-lived orbital stations. The next stage, based on accumulated engineering-technical experience and the material-technical base already laid, in his view, would be constructing extensive "settlements in the ether."

Even in his 1911-1912 work, K. E. Tsiolkovskiy sketched out his plan for conquering the interplanetary spaces. The scientist stressed that mastering of space in the solar system and the entire universe must begin not with the conquest of the natural objects in space (planets, asteroids and so on), but with the building of artificial settlements in space, of which the simplest form are orbital stations: "I speak not of reaching such giant planets as Jupiter, Saturn and the others," he explained in particular, "because a safe landing on them would take such an enormous amount of explosive that it does not pay even dreaming about such a landing, at the present. But it is easier to make them satellites, especially the distant ones .... [1, p 126].

The final plan for conquest of the universe with orbital stations was proposed by K. E. Tsiolkovskiy in 1926 in [7], bearing the explanatory subtitle "Pereizdaniye rabot 1903- i 1911 gg. s kotorymi izmeneniyami i dopolneniyami" [Republication of Works of 1903- and 1911 with Certain Changes and Supplements]. And even in a 1923 manuscript [8] he outlined the main juncture points in the program of building a system of orbital stations: "We take off in a celestial craft. [illegible] and we stay at a distance of 2000-3000 verst from earth, as its moon. In a not very long time there forms a colony, with implements, materials, machines and structures brought from earth. In a not very long time there develops an autonomous, even though at first limited industry...

"When life and technical industry have been consolidated in the ether and settlements have been formed around earth or in the asteroid belt, in a word, there where a surplus of diverse materials can be found for construction -- then there will no longer be the need to take monstrous reserves of explosives from earth" [8, sheet 5].

K. E. Tsiolkovskiy held that settlements outside the earth could be quite fully supplied with solar energy and proposed using as the construction material for space settlements, rockets and management of the economy the matter of the numerous asteroids. However, setting up the first extraterrestrial stations, he felt, could not be done without close contact with earth,

which must at the outset supply the stations with machines, materials and food and arrange for crew shift changes. But in the future "... on settling around in the earth in a multitude of rings, like Saturn's rings, ... people would increase by 100-1000 times the reserve of solar energy supplied them at the earth's surface. But man cannot be content with this and from his base conquered he must stretch out his arms for the rest of the solar energy, which is two billion times more than the earth receives.

"In this case, the eternal circular motion of earth must be replaced by a like circular path around the sun. This will mean moving still further from earth and becoming an independent planet, a satellite of the sun, a brother to earth" [1, p 125].

With time, in K. E. Tsiolkovskiy's opinion, these artificial planets of the solar system can be united into enormous "cities in the ether" and form a giant rings around the sun. Scientific-technical progress will differ little from the conditions of life on earth. Rotations of the rings will produce necessary gravitational forces for people to live on their inner surface and for the stability of the entire structure. Interestingly enough, K. E. Tsiolkovskiy's idea of a "ring" somewhat edged out, in time, F. Dyson's proposals on building around the sun a sphere on which earth civilization can continue developing. K. E. Tsiolkovskiy suggested that these rings of "cities in the ether" be built, with growing penetration into the universe, around stars whose radiation can become a source of energy and in whose vicinities there is matter for the construction of space cities. In a 1919 writing "Zhizn' v efire" [Life in the Ether] [9] he treated at length existence of "cities in the ether" cut free of contact with earth.

An interesting trait of K. E. Tsiolkovskiy, as scientist and thinker, was that, by devising various original projects, for example, those for orbital space stations, he was not confined to formulating and validating general ideas, but at the same time worked out an entire complex of specific scientific-technical tasks essential for successful implementing of the idea he advanced. It is just this trait of K. E. Tsiolkovskiy that was accented by Academician A. A. Blagonravov, in characterizing him as a scientist: "In Tsiolkovskiy's works one can see embryos of all, nearly without exception, scientific-technical directions gaining development in our country in the conquest of space. With exceptional accuracy he determined the successive path of advances in equipment for reaching this goal. Therefore it is quite natural that with each new achievement in this field we remember the name of Tsiolkovskiy, as a scientist who foresaw the culmination of these events, in some particular form" [10, p 483].

In the field of work on orbital space stations, K. E. Tsiolkovskiy is the originator of several classical ideas, which to some extent predetermined many features of the present space research program. The idea of achieving a closed biological cycle on these stations is the most important one, along with substantiating the actual idea of building space stations away from earth. Essentially, the idea of achieving a closed biological cycle amounts to the fact that plants and bacteria taken from earth give off oxygen with

the aid of solar energy and chemical elements, also taken from the earth, and form organic compounds, which in turn serve as food for men and animals. The scientist also proposed several designs of space hothouses, in which a closed biocycle would be achieved. He suggested, in particular, making these hothouses rotating in order to retain soil and people on their surface.

Of unquestioned interest are the various designs of orbital stations made up of sections fabricated on earth and brought there for assembly in space, as proposed by K. E. Tsiolkovskiy.

The scientist was particularly absorbed in the problem of setting up industry in space "industry in the ether," without which no cities could be founded away from earth. He returned to this theme many times. Even in a 1921 manuscript "Rasprostraneniye cheloveka v kosmose" [Propagation of Man in Space] [11], K. E. Tsiolkovskiy detailed such specific problems as building machine tools and equipment for use in space, the dimensions of residences and hothouses, the layout of ventilation, cooling and heating facilities for premises, building solar power units and the movement of cosmonauts in free space with flexible halyards, down to the design for a bath house.

In this same manuscript, K. E. Tsiolkovskiy, entranced by the grandiose prospects of conquering space and sensing that his ideas could distract him now into a rigorous scientific theory, made the following note for himself on one of the pages with large bold letters: "Begin to write out a complete theory of rockets" [11, sheet 18]. He successfully implemented this grandiose task in his further scientific creativity.

Many of the interesting proposals on building orbital stations were illustrated by the author himself in figures for the motion picture film "Space Voyage," for which the scientist was the scientific consultant (193 [illegible]) [12]. Some of these figures gained new vibrancy due to recent gains in world astronautics (man's entry into space, docking in orbit, the behavior of cosmonauts in weightlessness and during g-loads and many other areas).

As we have seen, the birth of the idea of building orbital stations can be found in the works of K. E. Tsiolkovskiy harking back to 1878-1879. This idea was clearly formulated by him in 1911-1912. The project of conquering interplanetary space with orbital stations was given by the author in a substantiated and complete form by the mid-1920's.

Acquaintance with the specific design proposals and the consistent development and deepening of the idea of building orbital stations in the creative journey of the scientist is helping us to even further unfold K. E. Tsiolkovskiy's role as the founder of modern astronautics. A comparison of his projects with those of modern orbital stations, and the broad complex of scientific research underway in space today graphically show the extraordinary far-sightedness of the scientist, his creative systematic approach to the problems discussed and his profound grasp of the full importance and complexity of the problems facing mankind in the conquest of space.

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9. Idem, "Zhizn' v efire" [Life in the Ether], 1919, Archives of the USSR Academy of Sciences, f 555, list 1, d 238 (first published in 1964).

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11. Idem, "Rasprostraneniye cheloveka v kosmose" [Propagation of Man in Space], 1921, Archives of the USSR Academy of Sciences, f 555, list 1, d 246.

12. Idem, "Al'bom kosmicheskikh puteshestviy" [Album of Space Voyages], 1933, Archives of the USSR Academy of Sciences, f 555, list 1, d 84 and 88 (first published in 1966).

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3. Space hothouses, ibid, f 555, list 1, d 84.
4. Cosmonauts in free space, ibid.
5. Designs of elements of space stations, ibid, f 555, list 1, d 246.
6. Interior view of orbital stations, ibid, f 555, list 1, d 84.
7. Rings of "cities in the ether" around planets of the solar system, ibid, f 555, list 1, d 238.